Metode optice in investigarea mediului

- **Refractometria**

  - metoda bazata pe masurarea indicelui de refractie

- **Polarimetria**

  - metoda bazata pe modificarea starii de polarizare a luminii.

- **Colorimetria**

  - metoda bazata pe absorbtia integrala a luminii in substanta.

- **Spectrofotometria**

  - metoda bazata pe inregistrarea spectrelor de emisie si absorbtie.

- **LIDAR (LIght Detection And Ranging)**

  - metoda bazata pe detectia luminii difuzate de catre impuritati

Legea Snellius-Descartes

Cazul: $n_1 < n_2$

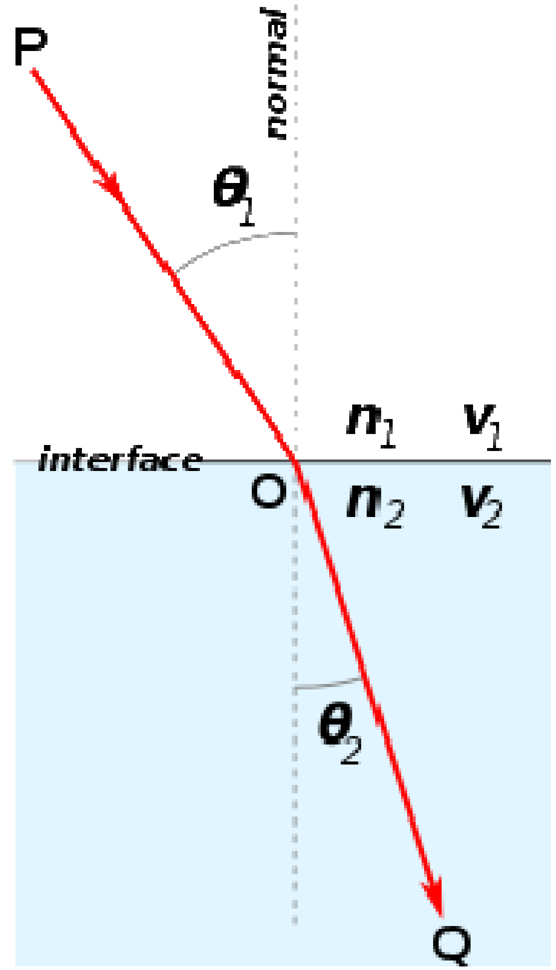
Refractia are loc cu apropiere de normala

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$n_1 \sin i = n_2 \sin r$$

La incidenta normala *i = 0* rezulta *r = 0*, a.i.

$$\frac{n_1}{n_2} = \frac{\sin r}{\sin i} = \frac{0}{0} = orice\ valoare$$



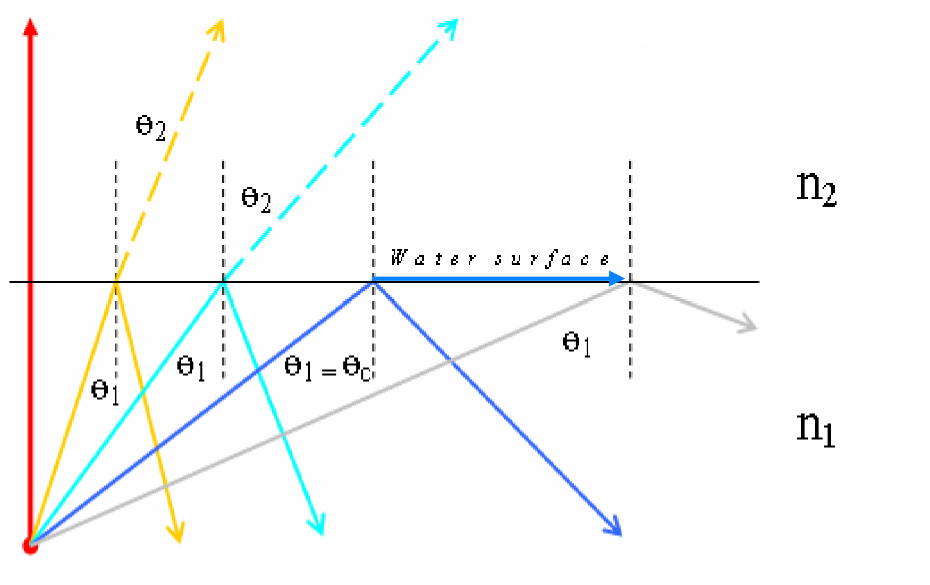
Nedeterminare maxima in compararea indicilor de refractie

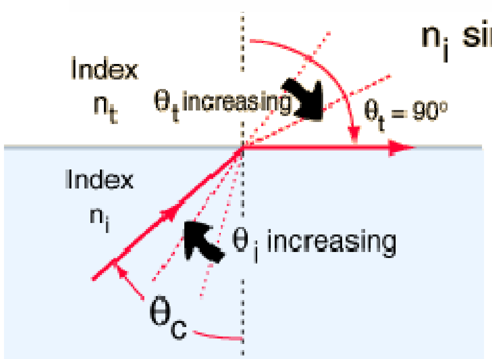
Reflexia totala interna. Unghiul limita.

Cazul: $n_1 > n_2$

Refractia are loc cu departarea de normala

Unghiul limita (unghi critic) **= unghiul de incidenta pentru care unghiul de refractie devine 90⁰**

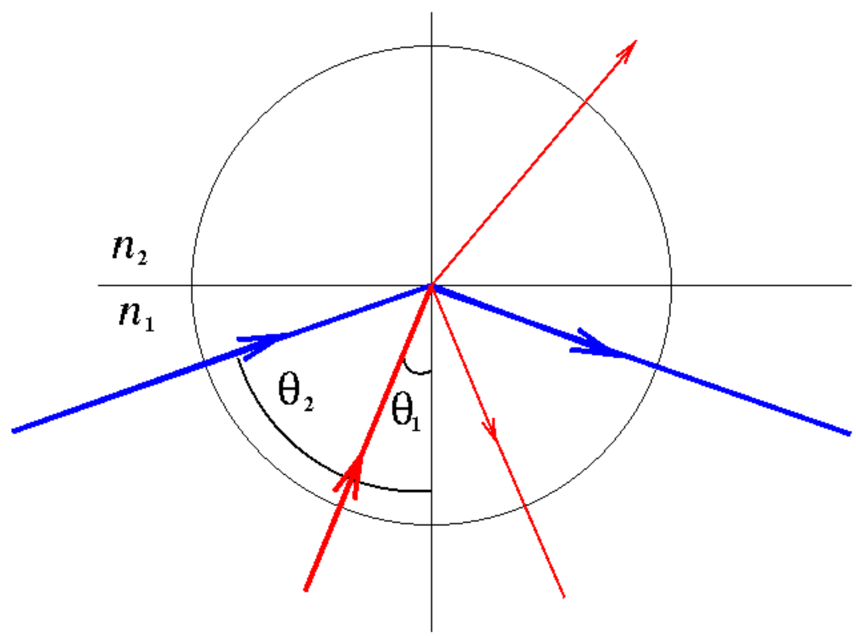




$n_i \sin \theta_c = n_t \sin 90°$

Threshold condition for total internal reflection.

$i_l = \theta_c$ $\quad n_1 \sin i_l = n_2$



Când unghiul de incidență este mai mare decât unghiul limită, toată lumina se întoarce în mediul din care a venit.

Principiul refractrometrului

Sensibilitatea maxima in compararea indicilor de refractie are loc la unghiul limita:

$$n_1 \sin i_l = n_2$$

Se pot pune in evidenta variatii de ordinul lui 10^{-3} - 10^{-8}

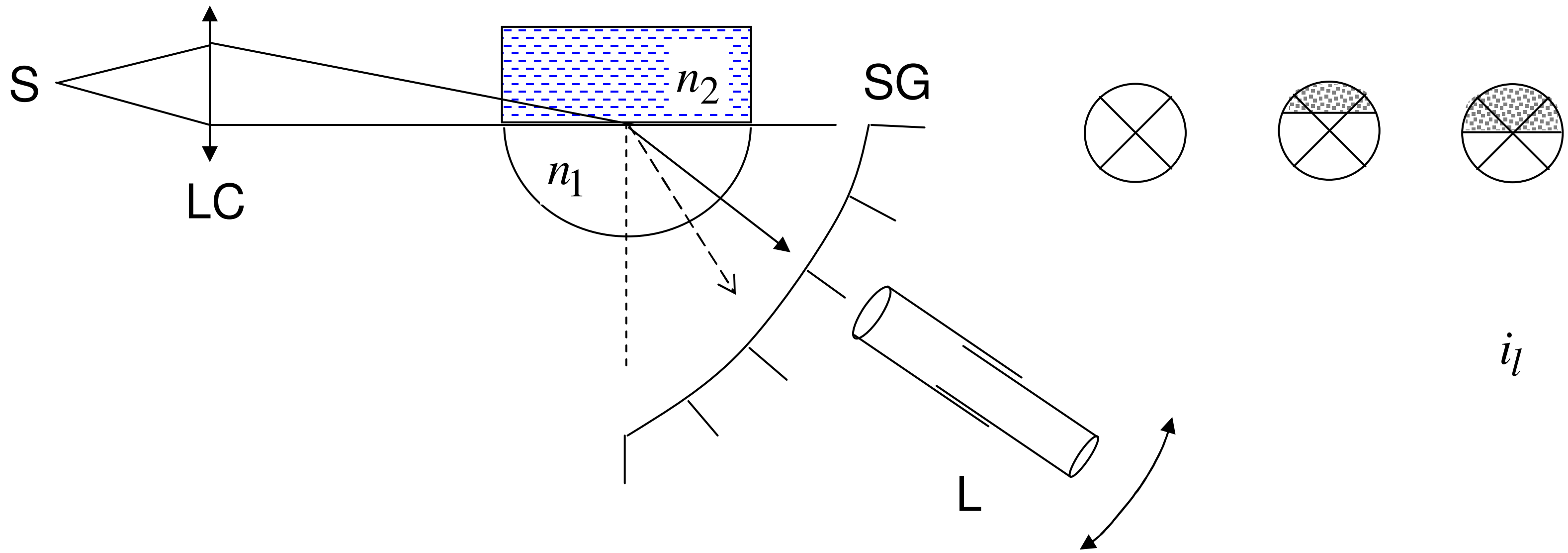
$$\Delta n_2 = n_2 - n_2' = n_1\left(\sin i_l - \sin i_l'\right) = 2n_1 \cos\frac{i_l + i_l'}{2}\sin\frac{i_l - i_l'}{2} = n_1 \cos i_l \cdot \Delta i_l$$

Sau prin diferentiere:

$$dn_2 = n_1 \cos i_l \cdot di_l$$

Estimare numerica: $n_1 \sim 1;\, 0.5 < \cos i_l < 1;\, di_l \sim 30\sec \sim 0.5\min \Rightarrow dn_2 \sim 0.00015$

Schema de principiu a refractometrului



S – sursa monocromatica (linia D a sodiului – 589.3 nm)

LC – lentila colimator

L – luneta

SG – sector gradat

OBSERVATIE: ***semicilindrul este facut dintr-un material transparent al carui indice de refractie este foarte bine cunoscut***.

Tipuri de refractometre

Refractometrul Pulfrich

- precizie la a 4-a zecimala.

Refractometrul Abbe

- precizie la a 3-a zecimala.

Refractometrul de imersie;

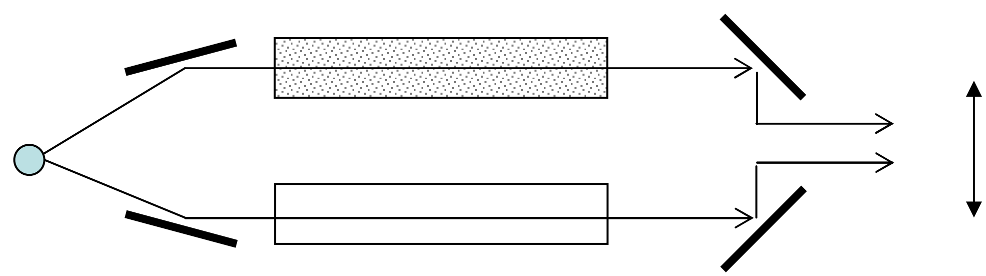
- precizie la a 5-a zecimala.

Refractometrul diferential;

- precizie la a 8-a zecimala.

Refractometrul interferential

- precizie la a 8-a zecimala.

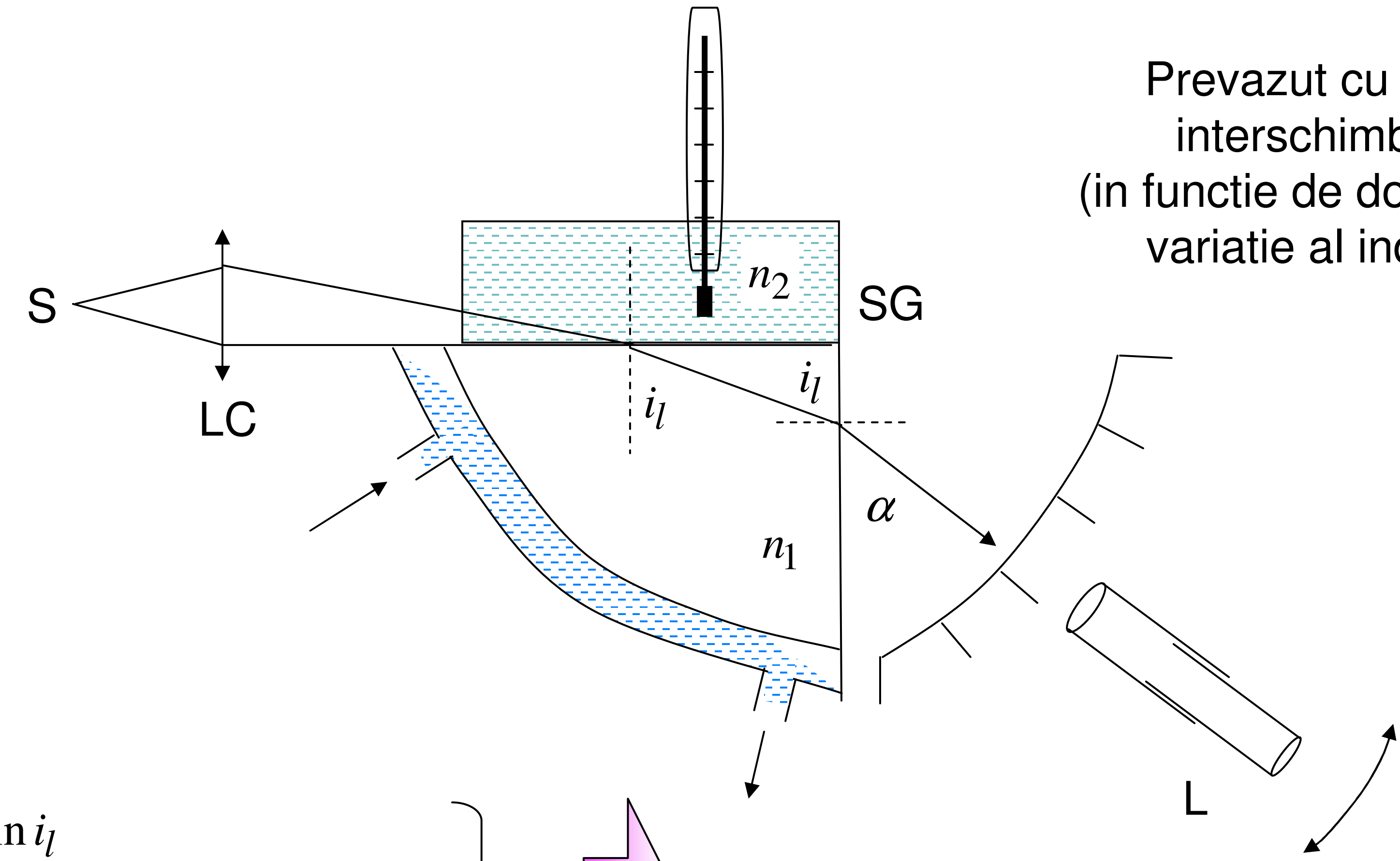


$$\delta = (n_1 - n_2) l$$

$$\Delta\varphi = \frac{2\pi}{\lambda} l (n_1 - n_2)$$

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2 \cos\Delta\varphi} = 4 I_0 \cos^2 \frac{\Delta\varphi}{2}$$

Refractometrul Pulfrich



Prevazut cu prisme interschimbabile (in functie de domeniul de variatie al indicelui)

$$n_2 = n_1 \sin i_l$$

$$n_1 \sin\left(\frac{\pi}{2} - i_l\right) = n_0 \sin\left(\frac{\pi}{2} - \alpha\right)$$

$$\Rightarrow \quad n_2 = \sqrt{n_1^2 - n_0^2 \cos^2 \alpha}$$

Refractometru portabil

Imaginea include campul vizual. Pe prisma refractometrului a fost pusa o picatura de lichid.

Diferite modele de refractometre

Traditional Abbe Refractometer
User obtains reading by lining up crosshairs, and reading graduations in the view. Note the external thermometer and the ports for circulating water.

Digital Display Abbe Refractometer
User still has to line up the crosshairs in the eyepiece, but the reading is displayed on the digital readout. Thermometer is now internal, but waterbath is still required for accurate measurements.

Multi-Wavelength Abbe Refractometer
Operates on same principles as Digital Display Abbe, but fitted with additional components with which to measure at different wavelengths. Also calculates Abbe number automatically. Waterbath still necessary for accuracy.

Modern Digital Laboratory Refractometer
Circulating water is no longer required for temperature control. The "crosshair" display is also replaced by push-buttons. Accuracy is increased to 5th or sometimes 6th decimal place of refractive index. Can link to a printer for hard copy or computer for remote operation.

thanks to ATAGO Co., Ltd. and www.atago.net for source images.

Refractometru digital

Light from an LED light source is focused on the underside or a prism element. When a liquid sample is applied to the measuring surface of the prism, some of the light is transmitted through the solution and lost; while the remaining light is reflected onto a linear array of photodiodes creating a shadow line. The refractive index is directly related to the position of the shadow line on the photodiodes. The more elements there are in the photodiode array, the more precise the readings will be, and the easier it will be to obtain readings for emulsions and other difficult-to-read fluids that form fuzzy shadow lines. Once the position of the shadow line has been automatically determined by the instrument, the internal software will correlate the position to refractive index, or to another unit of measure related to refractive index, and display a digital readout on an LCD or LED scale.

Digital handheld refractometers are generally more precise than traditional handheld refractometers, but less precise than most benchtop refractometers. They also may require a slightly larger amount of sample to read from (since the sample is not spread thinly against the prism. Users should look for an instrument that is capable of displaying the unit of measure of the substance (Brix, freezing point, boiling point, concentration, etc.). Nearly all digital refractometers feature Automatic Temperature Compensation (for Brix at least), but it is wise to double check this when purchasing.

Perspective

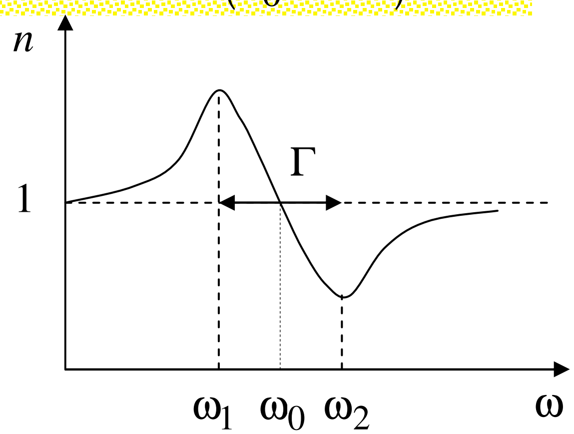
$$m\frac{d^2\vec{r}}{dt^2} = q\vec{E} - \gamma\frac{d\vec{r}}{dt} - k\vec{r} \qquad \ddot{\vec{r}} + \Gamma\dot{\vec{r}} + \omega_0^2\vec{r} = \frac{q}{m}\vec{E} \qquad \vec{r}_0 = \frac{\frac{q}{m}\vec{E}_0}{\left(\omega_0^2 - \omega^2\right) - i\omega\Gamma}$$

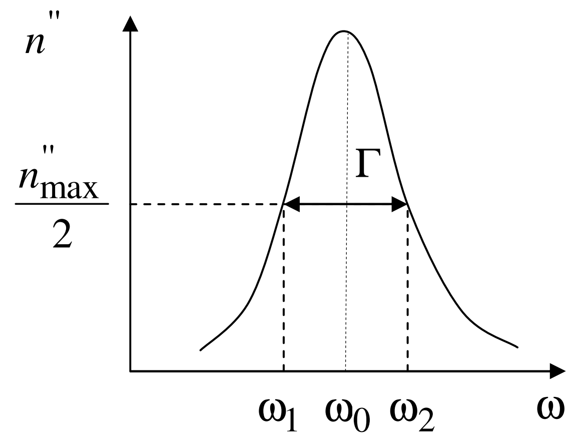
$$\vec{P} = Nq\vec{r} = \varepsilon_0\chi\vec{E} \quad \Rightarrow \quad \tilde{\chi}_e = \frac{Nq^2}{m\varepsilon_0}\cdot\frac{1}{\left(\omega_0^2 - \omega^2\right) - i\omega\Gamma}$$

$$\tilde{n} = \sqrt{\tilde{\varepsilon}_r} = \sqrt{1 + \tilde{\chi}_e} \quad \Rightarrow \quad \tilde{n}^2 = 1 + \tilde{\chi}_e = 1 + \frac{Nq^2}{m\varepsilon_0}\cdot\frac{1}{\left(\omega_0^2 - \omega^2\right) - i\omega\Gamma}$$

$$\tilde{n} = n + i\kappa$$

$$\begin{cases} n^2 - \kappa^2 = 1 + \dfrac{Nq^2}{m\varepsilon_0}\cdot\dfrac{\omega_0^2 - \omega^2}{\left(\omega_0^2 - \omega^2\right)^2 + \omega^2\Gamma^2} \\[2ex] 2n\kappa = \dfrac{Nq^2}{m\varepsilon_0}\cdot\dfrac{\omega\Gamma}{\left(\omega_0^2 - \omega^2\right)^2 + \omega^2\Gamma^2} \end{cases}$$



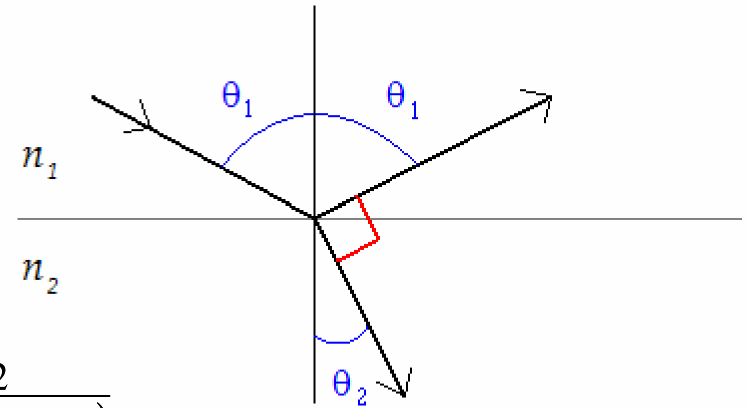


Refractometria va fi inlocuita de metodele spectrale

Polarimetria

Metode de polarizare a luminii

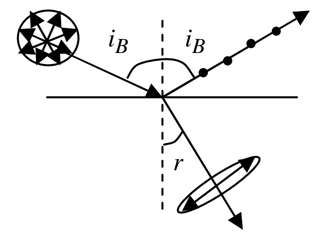
- prin reflexie - refractie



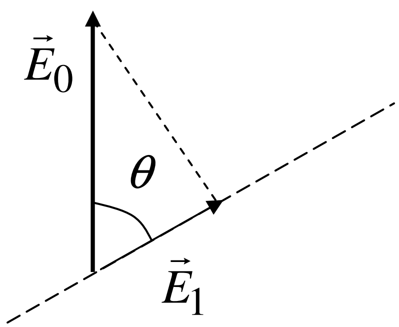
$$r_\perp \equiv \frac{E'_{1\perp}}{E_{1\perp}} = -\frac{\sin(\theta_1-\theta_2)}{\sin(\theta_1+\theta_2)} \qquad t_\perp \equiv \frac{E_{2\perp}}{E_{1\perp}} = \frac{2\cos\theta_1 \sin\theta_2}{\sin(\theta_1+\theta_2)}$$

$$r_{II} \equiv \frac{E'_{1II}}{E_{1II}} = -\frac{tg(\theta_1-\theta_2)}{tg(\theta_1+\theta_2)} \qquad t_{II} \equiv \frac{E_{2II}}{E_{1II}} = \frac{2\cos\theta_1 \sin\theta_2}{\sin(\theta_1+\theta_2)\cos(\theta_1-\theta_2)}$$

Incidenta Brewster: $\theta_1+\theta_2 = \frac{\pi}{2} \Rightarrow \begin{cases} r_{II} = 0 \\ tg(i_B) = n \end{cases}$



- prin dicroism (fenomenul de absorbtie selectiva) ⇒ Filtre polarizoare



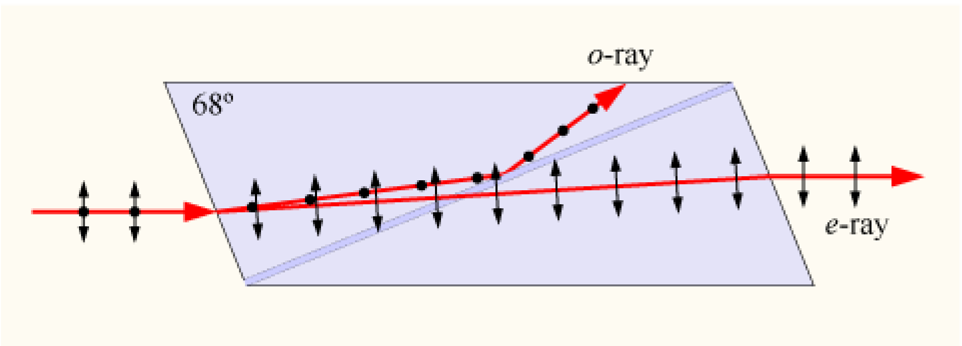
$$\left.\begin{array}{l} E_1 = E_0\cos\theta \\ I \sim |\vec{E}|^2 \end{array}\right\} \Rightarrow I = I_0\cos^2\theta$$

Polarimetria

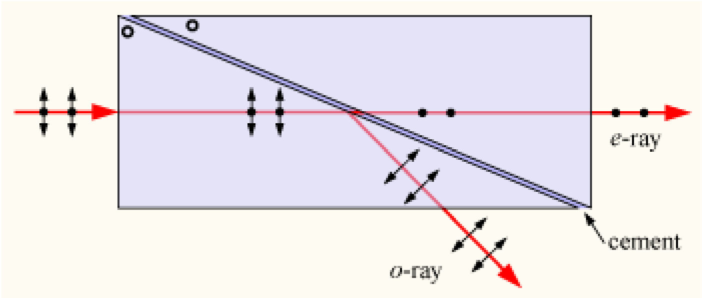
Metode de polarizare a luminii

- prin birefringenta

Cristal de calcit (Spat de Islanda)



Prisma Nicol

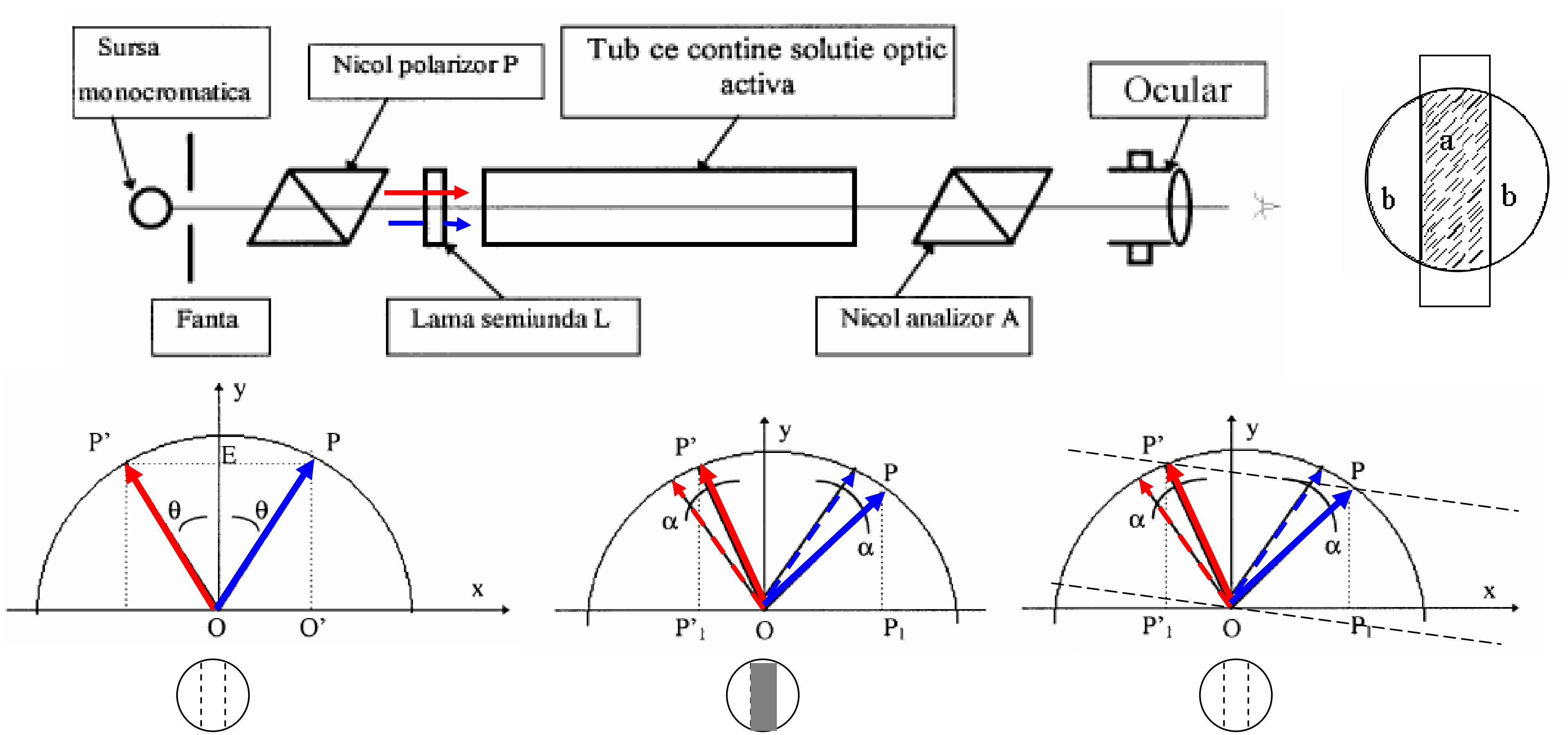


Prisma Glan-Thompson

Polarimetre

Polarimetrul cu camp de penumbra

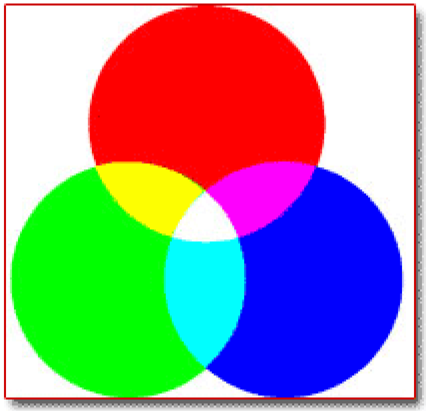
Polarimetrul cu lama semiunda



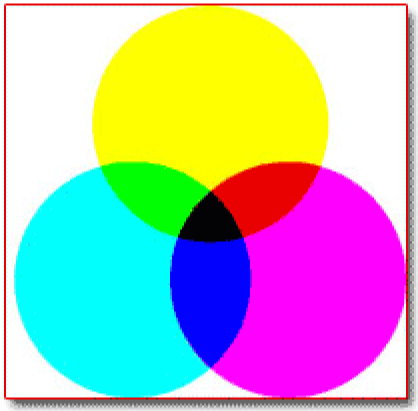
Colorimetria

Colorimetria studiaza legile dupa care are loc absorbtia luminii in substanta.

Culori primare (RVA)



Culori secundare (GCM)



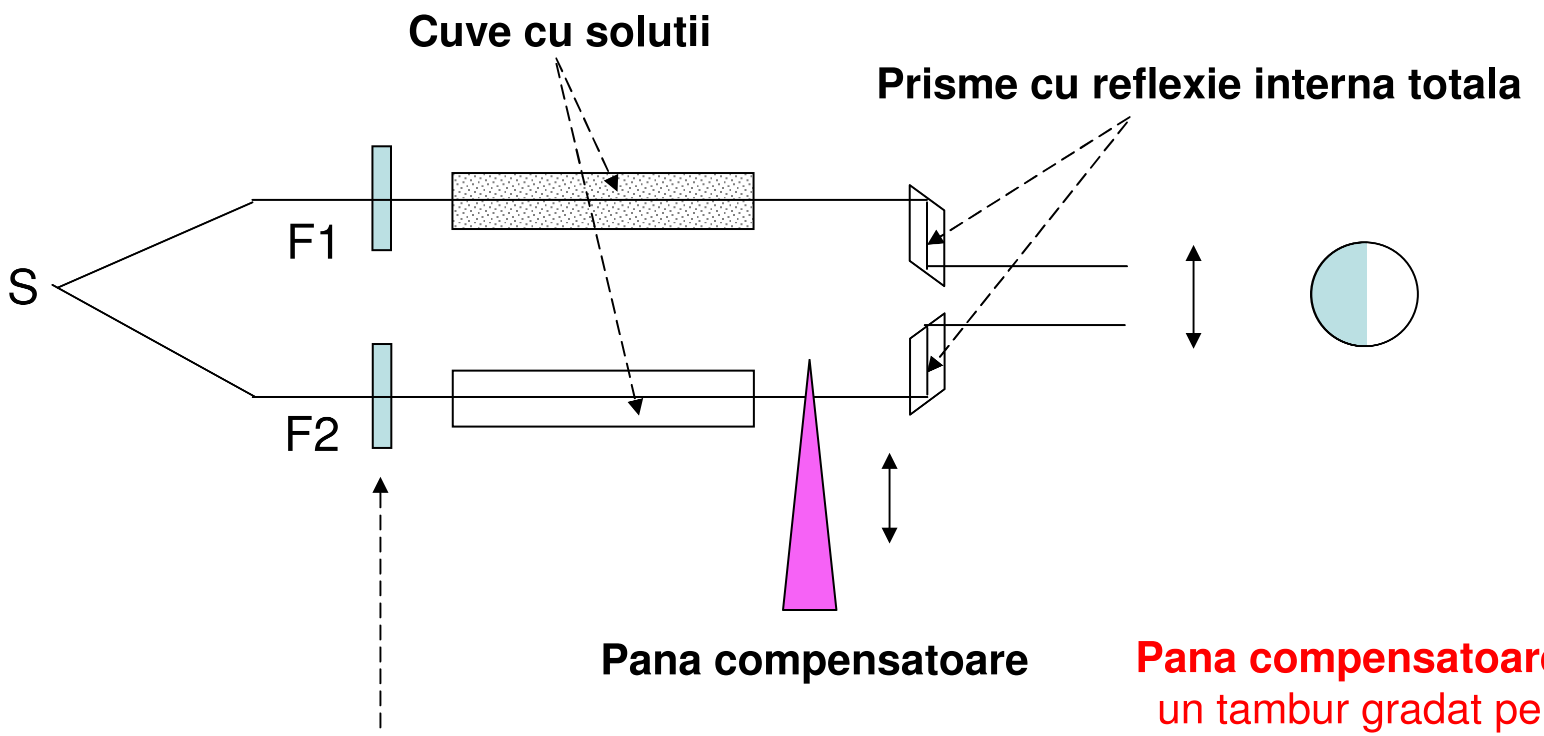
Legea Lambert-Beer

$$I(x) = I_0 \exp(-\alpha x) = I_0 \exp(-\varepsilon c x)$$

ε - coeficient de extinctie

$E = \varepsilon c$ - extinctie (densitate optica)

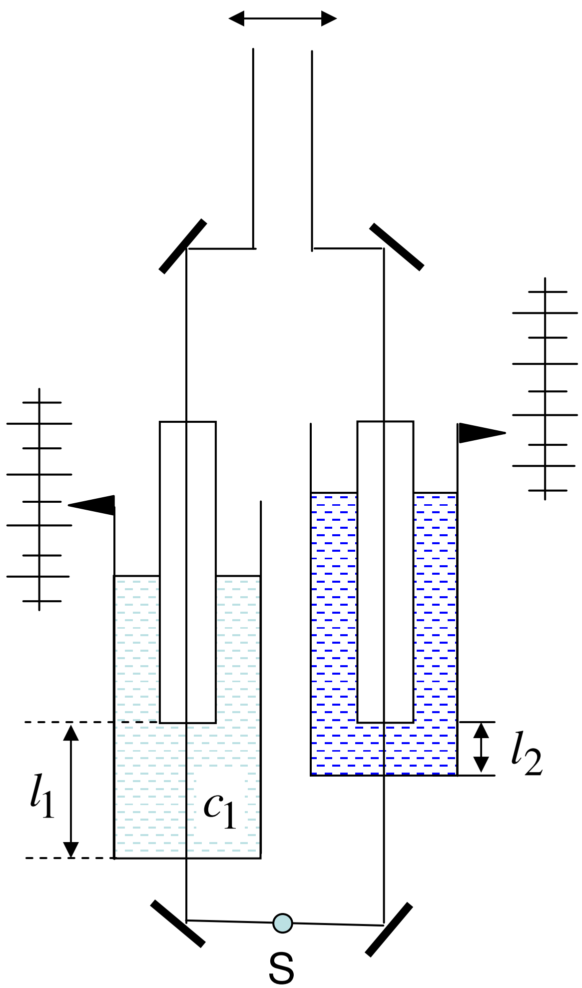
Colorimetrul Pulfrich



Filtrele F1 si F2 sunt filtre in culoarea complementara culorii solutiei de masurat. Astfel se elimina razele care nu sunt absorbite de solutie si care ar putea impresiona sistemul de observare

Pana compensatoare este cuplata la un tambur gradat pe care se pot citi direct diferentele dintre extinctiile celor doua solutii.

Colorimetrul Dubosq



$$\varepsilon_1 c_1 l_1 = \varepsilon_2 c_2 l_2$$

Cuve cu aceeasi substanta

$$c_1 l_1 = c_2 l_2$$

Relatie folosita pentru calculul concentratiei unei substante

Alte colorimetre

-Cu celula fotoelectrica;

-cu compensatie (fotocolorimertrul Lange);

-Fotocolorimetrul Pulfrich

Colorimetru digital